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THE BASICS

Several major species of locusts as well as significant populations of various grasshoppers threatened African simultaneously in the 1980s for the first time in 50 years. This infestation began in 1985 and 1986 after rains ended a severe, several-year drought and new, green vegetation allowed these pest species to proliferate. Several grasshopper species in the West African Sahel reached levels high enough to result in large-scale control efforts. Also, a major plague of Desert Locusts began in countries around the Red Sea, with swarms moving west across the Sahelian countries. By November, 1988, swarms of the Desert Locust extended from Mauritania and Senegal in the west to Iraq, Iran, and Kuwait in the east and some fragments of swarms reached the Caribbean.

The recent plague caught African nations and donors unprepared because the infrastructure to fight these insects had deteriorated in the decades since the last major problem. For donors such as the U.S. Agency for International Development, these insect problems caused shifts in funds, operations, and programs to cope with the apparent emergency. The Desert Locust plague ended in 1989 despite predictions that it would continue for several years But longer term issues remain (see box A). Experts differ widely in their assessment of the significance of grasshopper and locust outbreaks relative to other pest problems and national level crop damage they cause; the information base on which control decisions were made is deficient; no sound technological alternatives exist for chemical pesticides; and education and training for the next generation of experts seems inadequate.

Locusts and Grasshoppers

Some 200 grasshopper and locust species, with different food preferences and geographic distribution, are agricultural pests in Africa. A smaller number cause the majority of concern, including the Desert Locust and Senegalese Grasshopper (see figure 1). Different species can invade virtually all of the continent, as well as affect the Near East and Southwest Asia. Locust and grasshopper species, with varied biological characteristics, cause recurrent problems. Locust upsurges are usually attributable to one species in a given area and they occur episodically. Grasshopper infestations often involve a number of different species and cause agricultural damage each year. The Sahelian region is particularly vulnerable.

Locusts and some grasshoppers become a serious problem when they breed rapidly, become heavily concentrated, and undergo a biological transformation to the gregarious phase. Each insect in a gregarious group (a band of young hoppers or a swarm of adults) can eat up to its own weight per day and swarms may contain millions of insects and migrate up to 1,000 km in a week. A plague occurs when many gregarious bands and swarms occur over a large area in different regions.

Damage to crops and the other vegetation is not evenly distributed but often localized, like damage from a tornado, even during a plague. The reasons for the start of an upsurge of locusts or aggregating grasshoppers are relatively well-known-bountiful rainfall and the availability of new vegetation–although the inability to forecast weather precludes accurate prediction of insect build-up The reasons for plagues' declines are less clear. Specifically, the importance of control in declines is hotly debated.

Organizations Involved in Controlling Locusts and Grasshoppers

The U.N. Food and Agriculture Organization (FAO) has coordinated international locust control efforts since the 1950s, important because locust swarms migrate across national boundaries. African national crop protection services and regional organizations supplanted the English and French colonial locust control organizations in the 1960s. Three semiautonomous regional organizations (OCLALAV for West Africa, the Desert Locust Control Organization for East Africa, and the International Red Locust Control Organization for Central and Southern Africa) conduct survey and control efforts in most of sub-Saharan Africa, where national crop protection services are less well-developed than elsewhere. Three regional FAO commissions in Northwest Africa, the Near East, and Southwest Asia, cover areas where control is handled primarily by the national crop protection agencies; they coordinate surveys, control, training, and research.

Box A–An Open Letter to OTA's Readers: A Time for Caution

Africa recently experienced the largest simultaneous upsurges of several important locust and grasshopper pests in 50 years. Public and private donors spent approximately $275 million to control these pests in at least 23 countries from 1986 until mid-1989. Some African countries spent a significant amount of their own scarce funds as well. The U.S. Government provided some $60 million worth of aircraft, pesticides, and technical assistance (usually by Americans), in that order. Some claim this is the first time a Desert Locust plague has been stopped in its tracks and that the control program deserves full credit. They say that chemical control is virtually the only technological option against locust swarms today, and that other effective and safe control methods are at least a decade away. They seem to be right.

Yet, others contend that the weather contributed more than control to the insects' decline. They say officials should not take so much credit but perhaps more responsibility: for the mostly uncounted financial, health, and environmental costs of insecticide-based control programs; for using funds for emergency efforts that might have been better spent on long term development efforts; and for focusing on a few insects that, while highly visible, do not cause crop losses as great as some other agricultural pests. They also seem to be right.

The material in this report raises some unsettling questions about U.S. policy and the use of current technology in locust and grasshopper control programs in Africa. Some of OTA's findings are clear; others are highly qualified, reflecting lack of consensus among experts. In each instance in the chapters that follow, OTA sets out the relative degree of agreement among experts, describes which parties fall into which camps, and teases out implications of the disagreement. Such treatment has decreased but probably not eliminated the controversial nature of some of our findings and these findings are the base on which OTA's further analysis is built. Therefore, some might say OTA's report is built on a foundation of sand. OTA is inclined to state that certain U.S. policies are shaky, instead.

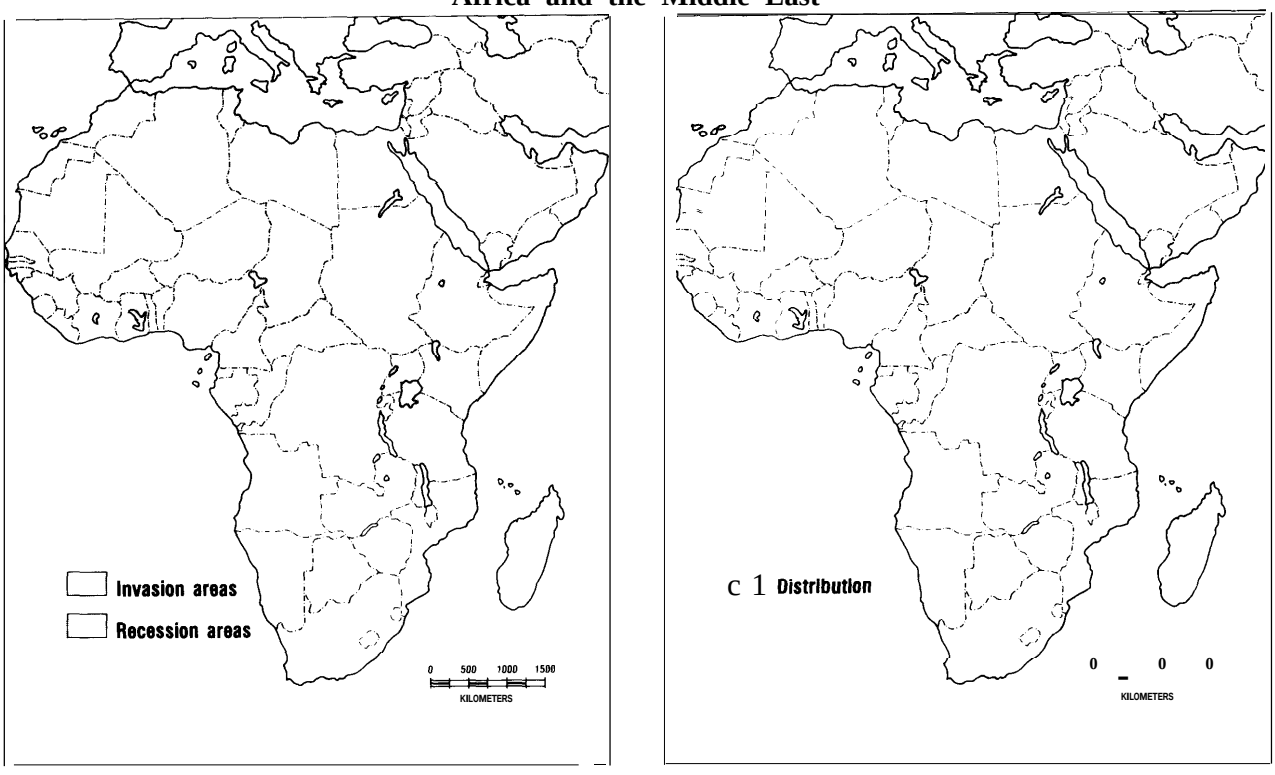
The causes for some questionable policy choices are understandable. Locusts and grasshoppers, by their ability to increase rapidly and sometimes to cause near-total destruction at localized sites, create an overwhelming and seemingly irresistible pressure for African and donor officials to take action. Such policymakers are well motivated and want to save crops and avoid famine. However, famine and national-level crop loss do not seem to be directly related to the impact of locust and grasshopper upsurges. In 1986, for example, these insects apparently caused overall crop loss of a little less than 1 percent in the 9 most affected African countries.

OTA finds that the U.S. response to the African grasshopper and locust outbreaks commonly has been based on faulty assumptions like the assumption that locust and grasshopper outbreaks lead to famine. It is time to lay better groundwork for U.S. pest management strategies in Africa. This will not be easy because of the multiple and conflicting motivations of people involved. Scientists want to be correct. Farmers and herders want to avoid risk and be productive. Policymakers want to be effective and individual nations want to preserve sovereignty. Certainly scientists' and policymakers' thoughtful assessments of grasshopper/locust situations in Africa differ markedly. Farmers' and herders' voices are not apparent in discussions of locusts and grasshoppers so their assessment of recent experience is not known, at least to OTA.

In any subject where reasonable disagreement exists, caution in making policy seems warranted. Therefore, OTA may seem to have provided more questions than answers here, finding that clear-cut options would not likely be as useful, for example, as oversight questions. Fortunately, the recent upsurges of locusts and grasshoppers seem to have passed. This is a propitious time, then, for Congress and the other concerned agencies to take the time needed to assess realistically the effects of the recent widespread spraying, and prepare for the future. For the insects WILL be back although no one can predict when, and most experts agree that improving preparedness could have solid paybacks the next time. By doing so, we might have more technological options, we might be more able to prevent problems before they grow so large as to limit policy choices, and we might be able to keep a better perspective on the overall intent–ensuring the most effective use of U.S. aid money for the development of Africa's poor.

SOURCE: Office of Technology Assessment, 1990.

Figure l-Distribution of Two Major Species of Locust and Aggregating Grasshoppers in Africa and the Middle East



Desert Locust **Senegalese Grasshopper**

SOURCE: TAMS Consultants, Inc. and Consortium for International Crop Protection, Locust *and Grasshopper Control in Africa/Asia: A Programmatic Environmental Assessment,* Main Report, contractor report prepared for the U.S. Agency for International Development, March 1989, pp. C-7, C-19.

The African national crop protection services, usually under the Ministry of Agriculture, are the major national organizations responsible for grasshopper control and they take over when problems exceed the capacity of individual farmers. They carried out ground spraying in the recent campaigns, sometimes assisted by farmer groups. Aerial spraying, often executed under regional or donor auspices in the Sahel but by national agencies in the Maghreb, was used for more extensive or remote infestations.

Donors contributed some $275 million from 1986 through mid-1989 to locust and grasshopper control, mainly in Northwest Africa and the Sahel. The United States gave $59 million, about 20 percent of the donor funds (tables 1 and 2). U.S. aid provides assistance primarily through the U.S. Agency for International Development (USAID). The Office of Foreign Disaster Assistance is responsible for short-term aid (3 to 6 months) whale regional bureaus and the Bureau for Science and Technology provide longer term aid.

As a result of donor and African countries' efforts, approximately 4.6 million ha of land in 10 Sahelian and West African countries received aerial or ground insecticide treatments in 1986 and 1987, mostly against grasshoppers. In 1988,10 million ha were sprayed in Northwest and West Africa, mostly against Desert Locusts and approximately 13 million liters of insecticides were used, mostly in Northwest Africa, at a total cost of about $100 million.

Controlling Grasshoppers and Locusts

Most traditional methods have been replaced by the use of chemical insecticides, at least in official programs. The most effective traditional

Table I-Donor Assistance to Locust and Grasshopper Control Programs, 1986-89 (U.S. dollars/calendar year)

Donors	1986	1987[a]	1988	1989 (Jan.-May)	Total
Bilateral donors:					
Algeria	50,000	146,882	180,000	o	376,882
Australia	0	0	***205,000***	0	205,000
Austria	0	0	***29,041***	0	29,041
Belgium	130,000	266,714	***500,000***	1,300,000	2,1%,714
Canada	3,014,500	2,802,238*	***2,243,000***	***343,000***	8,402,738
China	500,000		***40,000***	120,000	660,000
Denmark	692,500	635,369	***2,813,068***	2,400,000	6,540,937
Finland	400,000	0	***208,455***	75,000	683,455
France	1,792,537	3,491,738	***6,030,127***	3,150,000	14,464,402
Germany (FR)	3,025,887	6,209,031	***11,992,000***	14,250,000	35,476,918
Greece	50,000	0	160,000	0	210,000
Indonesia	0	10,000	25,000	0	35,000
Iran	0	0*	7,500	0	7,500*
Israel	0		0	0	
Italy	2,659,000	2,471,386*	2,994,675	1,000,000	9,125,061
Japan	1,288,000		4,100,368	13,620,000	19,008,368
Kuwait	0	o	1,000,000	0	1,000,000
Libya	0	0	1,212,000	0	1,212,000
Luxembourg	0	**140,000**	244,000	0	384,000
Morocco	20,000	o	320,000	0	340,000
Netherlands	2,350,000	1,850,000	6,592,347	0	10,792,347
Nigeria	0	0	400,000	0	400,000
Norway	3,127,000	1,500,000	1,615,000	2,000,000	8,242,000
Portugal	0	0	606,000	0	606,000
Qatar	0	0	12,000	0	12,000
Saudi Arabia	0	0	2,860,000	0	2,860,000
Spain	62,511	0	2,440,000	0	2,502,511
Sweden	1,185,929	0	2,599,386	0	3,785,315
Switzerland	403,000	92,790	944,268	338,000	1,778,058
Thailand	11,000	0	0	0	11,000
Tunisia	0	0	90,000	0	90,000
Turkey	0	0	500,000	0	500,000
United Kingdom	1,909,183	987,687	5,800,000	***207,000***	8,903,870
USAID	9,1%,245	6,983,332*	21,599,859	***12,000,000***	49,779,436
U.S.S.R.	o		1,376,000	0	1,376,000
Yugoslavia	64,000	o	_ 0	0	64,000
Subtotal bilateral donors	31,931,292	27,587,167	**81,739,094**	**50,803,000**	**192,060,553**

Table l-Donor Assistance to Locust and Grasshopper Control Programs, 1986-89-Continued (U.S. dollars/calendar year) Continued

Donors	1986	1987[a]	1988	1989 (Jan.-May)	Total
Multilateral donors:					
African Development Bank	165,000	0	200,000	6,019,730	6,384,730
Banque Africaine de Developpement Africain (BADEA)	750,000	0	0	0	750,000
European Economic Community (EEC)	10,739,981	2,348,674	9,600,143	400,000	23,088,798
Islamic Development Bank	0	0	14,400,000	2,044,000	16,444,000
Organization of African Unity (OAU)	0	321,430	300,000	0	621,430
Organization of Petroleum Exporting Countries (OPEC)	300,000	0	39,000	0	339,000
UN Children's Fund (UNICEF)	86,000	*	10,000[c]	0	%,000
UN Development Program (UNDP)	1,839,000	54,000[b]	2,926,332	0	4,819,332
UN Environment Program (UNEP)	0	o	48,405	0	48,405
UN Food and Agriculture Organization (FAO)	2,601,000	20,000	4,700,000	610,000	7,931,000
UN World Food Program (WFP)	18,000	0	0	0	18,000
UN World Health Organization (wHo)	4,480	0	0	0	4,480
Subtotal multilateral donors	**16,503,461**	**2,744,104**	**32,223,880**	**9,073,730**	**60,545,175**
Non-Governmental Organizations	**1,211,460**	**133,000[c]**	**1,111,000**	**0**	**2,455,460**
Total	49,646,213	30,464,271[a] + 20,000,000[d] 50,464,271	115,073,974	59,876,730	255,061,188 + 20,000,000[d] 2_7_5 . -
USAID as percent of total	**18.5%**	**22.9%**	**18.7%**	**20.0%**	**19.5%**

NOTES:
[a] "Amount unknown (1987).
[b] Includes only assistance to Sahelian and West African countries.
[c] Includes only assistance to two of four recipient countries.
[d] Includes only assistance from section aid to Gambia.
[e] An additional $20 million was given by donors for programs in Northwest African countries, Sudan, Ethiopia, and Yemen (Jeremy Roffey, Emergency Center for Locust Operations, FAO, personal communication, June 26, 1989).

SOURCES:
Column 1: Jeremy Roffey, "1986 Funding Chart for Grasshopper and Locust campaigns in Africa" (Emergency Centre for Locust Operations, U.N. Food and Agriculture Organization, Rome, December 1986).
Column 2: U.N. Food and Agriculture Organization, "Report of the Meeting on the Evaluation of the 1987 Grasshopper Campaign in the Sahel, Annex V (Emergency Centre for Locust Operations, Rome, December 1987).
Columns 3 and 4: U.N. Food and Agriculture Organization, "Assistance Provided to Countries and Regional Organizations," Report of the Thirtieth Session of the FAO Desert Locust Control Committee, AGP:DLCC/89/4, Rome, Italy, June 12-16, 1989.

Table 2–U.S. Assistance to Locust/Grasshopper Programs, Fiscal Years 1986-89

country	1986	1987	1988	1989	Dollars
Sahel and West Africa					
Burkina Faso	$268,800	$5&,&2	0	0	$860,532
Cameroon	200.000		0		400,000
Cape Verde	‘ o	‘ o	75,000	25,(X)8	100,000
Chad	990,841	1,254,211	1,305.730	o	3550,782
Gambia	35,000	594,898	( )[a]	25,000	654,898
Guinea Bissau	29,000	290,320	0	0	319,320
Mali	1,287,080	1,012,433	1,775,110	200,000	4,274,623
Mauritania	154,000	227,500	1,446,964	866,256	2,694,720
Niger	61,000	337,386	1,199,647	317,000	1,915,033
Sénégal	1,657,349	1,923,752	245,892	3,362,320	7,189,313
Sahel Regional	244,000	0	0	0	244,000
East and Southern Africa					
Botswana	1,183,587	0	0	0	1,183,587
Ethiopia	75,000	380,516	407,820	13,800	877,136
Sudan	1,024,948	600,000	662,415	173,713	2,461,076
Tanzania	50,000	0	0	0	50,000
Zaire	10,860	o	0	0	10,860
Zambia	100,000	0	0	o	100,000
East Africa Regional	0	0	0	0	0
Northern Africa and S.W. Asia					
Algeria	0	0	1,070,032	18,866	1,088,898
Jordan	0	0		152,600	152,600
Morocco	0	0	5,295,71!	10,308,974	15,985,203
Pakistan	0	0	o	2,000,000	2,000,000
Tunisia	0	0	1,361,447	1,410,535	2,771,982
Yemen	0	135,598	0	0	135,598
African Regional	75347	o	5,578,414	4,123,988	9,777,749
Total dollars	**$7,446,812**	**$7,548,346**	**$20,424,184**	**$22,998,052**	**$58,797,910**
Amount of total granted to FAO	**4,084,587**	**358,000**	**2,465,000**	**1,508,910**	**8,416,497**
Amount of total, OFDA funds[b,c]	**7,171,012**	**6,384,059**	**9,643,950**	**5,585,652**	**28,784,673**

NOTES:

[a] Assistance to Gambia in 1988 and some in 1989 included in amount for Senegal.

[b] U.S. assistance consists of OFDA funds, USAID mission funds, Africa or Asia/Near East Bureau regional funds, and some local currency. In FY 1988, OFDA contributed $9,643,950, the missions $4,840,600, the regional programs $6,689,656, and local currency $2,350,464, for a grand total of $23,524,670. In FY 1989, OFDA contributed $5,585,652, the missions $15,847,400, the regional programs $1,565,000 and local currency $1,850,343, for a grand total of $24,848,395. Thus, the percent of OFDA funding decreased significantly in 1988 and 1989.

[c] Information in this line from John Gelb, 1989, below.

SOURCES:

1986–John Gelb, Office of Foreign Disaster Assistance, AID, "USG Contributions to Locust/Grasshopper Threat in Africa - FY 1986 as of September 30, 1986," n.d.

1987–Office of Foreign Disaster Assistance, "Insect Infestation," OFDA Annual Report Fiscal Year 1987 (Washington, DC: USAID, 1988).

1988–Office of Foreign Disaster Assistance, "Insect Infestation," OFDA Annual Report Fiscal Year 1988 (draft) (Washington, DC: USAID, 1989).

1989–John Gelb, Office of Foreign Disaster Assistance, "U.S. A.I.D. Support, Desert Locust Task Force, FY 1987-89," dated July 22-23, 1989. Due to the decline of the locust problem in early 1989, some of the funds allocated have been reprogrammed for other crop protection activities.

method consists of driving hoppers into trenches and then burning, drowning, or crushing them. Arsenic was the first chemical used against these pests. Ground and then aerial spraying of persistent organochlorines (dieldrin and BHC) became the preferred control method in the 1950s. But dieldrin was banned, first in the United States and then Europe, in the late 1970s because of its environmental and health hazards. Fenitrothion and malathion were the major chemicals used in the recent campaign.

WHAT IS THE PROBLEM?

Most people, and many locust experts, view the recent upsurges of locusts and grasshoppers as a disaster threatening Africa's already precarious food security. Swarms put political pressure on national leaders and donors to mount aggressive, chemical control. National government and donor policies are based on the assumptions that locusts are a serious problem, that pesticides are the way to control them, and that control programs benefit low-resource farmers and herders substantially. Others disagreewith these assureptions; OTA also finds theassumptionsquestionable. Experts differ over:

- the insects' impact on food production and whether they cause famine;
- the effectiveness and cost-efficiency of control programs based exclusively on chemical insecticides;
- insecticides' impacts on human health and safety and the environment; and
- how control should be organized and which strategies should be pursued.

Locusts and grasshoppers are relatively minor pests even during upsurges in terms of overall crop losses, although localized damage maybe devastating for short periods. Economic losses depend on which plants are affected and their age so damage is unevenly distributed among commercial and subsistence farmers and herders. The link between famine or food shortages and locusts and grasshoppers is questionable. Locusts and grasshoppers can harm national agricultural production if they devastate areas crucial to a nation's economy (as in 1954 when Desert Locusts destroyed citrus trees in Morocco's Seuss Valley). This type of damage did not occur in the recent plague, however. Damage was less than drought would produce, and losses were localized, with the aggregate level of reduction in 1986 in the nine countries most affected by grasshoppers down only about 1.0 percent in weight and 1.5 percent in value, according to FAO and USAID estimates.

The Effectiveness of Control

The efficacy, efficiency, and equitability of locust and grasshopper control programs are undocumented. While insecticides can protect standing crops, their ability to end or prevent plagues is not clear. Nor have the economic benefits of crop protection been demonstrated. Experts' views on reasons for the decline of plagues range from "entirely due to weather" to "control programs were the major factors curtailing the plague." Key data for resolving these differences of opinion are lacking. It seems that, in some places, at certain times, properly administered control can help interrupt the sequence of events that could contribute to an upsurge's spread. While climate is the dominant factor, it seems that chemical control can play an important role, at least on the national scale.

Various insecticides have different relative effectiveness based on ingredients and formulations. A number were used in the recent campaigns, often in ways that reduced or negated their effectiveness, e.g., when temperatures and wind speeds were beyond recommended ranges, after insects had laid eggs, or when some areas were unnecessarily resprayed. Chlorinated hydrocarbons–dieldrin, lindane, and BHC–were eliminated from U.S.-supported efforts after USAID was sued by environmental groups in 1975. FAO, however, advocates continued use of dieldrin, claiming it is effective, cost-effective, and not harmful. Some European donors still supply lindane. All three were used in the most recent African locust and grasshopper campaign, although in small amounts, and unused stocks remain. The insecticides with USAID's qualified approval for use against grasshoppers and locusts changes over time. That list is not totally congruent with insecticides registered for use against grasshoppers and locusts in the United States by the U.S. Environmental Protection Agency (EPA). Reliable field measurements of spraying's impact on insects and nontarget organisms have not been made.

The recent control efforts were plagued by problems. Opportunities to spray hopper bands, when the insects were more concentrated, were missed because of the:

- inaccessibility of breeding areas;
- lack of vehicles, communication equipment, and trained personnel;
- governments' not allowing cross-border survey or spray operations;
- crop protection services' priority to protect cropland; and
- wars and civil strife.

Additional problems existed in the earliest part of the campaign: lack of preparedness of staff, impassability of roads in the rainy season, donors' diverse policies, and late arrival of equipment and pesticides.

Costs of the control programs in Africa were high, especially because chemicals had to be imported and transportation costs were high–from $15 to $30 per hectare in 1986, compared to $5.50 to $9.00 per hectare for grasshopper control in the United States. The cost-effectiveness of control has not been demonstrated. Some evidence exists that in 1986 the value of production saved in the nine most affected countries did not equal or exceed the costs of control: a total of $40 million for control to save $46 million of production. The data on which this conclusion is based are few, however, partly due to donors lack of effort in collecting them and partly due to problems inherent in the effort.

Impacts on Health and the Environment

Safe and environmentally sound use of insecticides was not ensured during the recent locust and grasshopper campaigns. Application, storage, and disposal were not monitored and the cumulative effects of chemicals used in various agricultural and health programs were not taken into account. Case reports exist of toxic human exposure, especially to those who handled insecticides. Insufficient attention was paid to the effects of locust and grasshopper spraying on scarce food and water supplies. Empty pesticide containers have been used to store food and water.

Various pesticides used in the campaign are known to have harmful effects on nontarget organisms (e.g., fenitrothion to birds and fish and carbaryl to honeybees) and some of these occurred. Honeybee colonies were killed in Tunisia and 30 sheep died after grazing on pesticide-contaminated land. Insecticide residues were found in the soil in Mali and Morocco. Storage and disposal of surplus insecticides and containers is recognized as a major problem by African governments, donors, and FAO. Problems such as inadequate packaging and labeling have resulted in contamination and loss of effectiveness.

Institutional and Political Aspects of Control

Most African national and regional agencies and donor institutions are not equipped to deal with locusts and grasshoppers on a long-term basis. Commonly, development goals are sacrificed in favor of emergency management. In Africa, civil strife and long-standing border disputes constrained access to some of the most important areas for conducting insect surveys and control.

The shortcomings of Chad's national crop protection service in dealing with locust and grasshopper programs were typical: imprecise data on pests, vehicle breakdown, poor training, shortage of survey materials, inadequate preparations before the rainy season, inaccurate treatment figures, and no monitoring of adverse effects. Donor organizations exhibite a different set of shortcoming s: organizational shifts and redirection of funds from development to crisis management, and lack of experts experienced with technical aspects of the program and with African situations.

STRATEGIES FOR THE FUTURE

USAID made commendable attempts to: 1) coordinate its efforts with U.S. agencies; foreign donors and African officials; 2) provide training to

Africans and its own personnel; and 3) stress sound selection, storage, application, and disposal of insecticides.

The Office of Foreign Disaster Assistance (OFDA) Desert Locust Task Force was the focal point for coordination. It held weekly meetings, bringing together experts from the U.S. Department of Agriculture's Agricultural Plant Health and Inspection Service and the Forest Service, the EPA, and the U.S. Geological Survey (USGS). Also, the Task Force reviewed its work annually and prepared a helpful *Locust/Grasshopper Management Operations Guidebook*. USAID held 10 training workshops and funded additional training by FAO and a regional organization.

USAID advocated use of less toxic insecticides, a ban on dieldrin, and improved disposal of containers and surplus stocks. Ako, USAID supplied protective clothing for pesticide applicators and tested applicators' cholinesterase evels in one country. USAID clearly prevailed in reducing dieldrin's use. USAID attempted to make control more efficient and less costly by pre-positioning chemicals in Europe and using remote sensing (greenness maps) to identify areas for ground surveys.

How To Do Better Next Time

Overall, the results of locust and grasshopper control were disappointing. Donors cannot afford to fund expensive control campaigns without addressing fundamental questions regarding goals and implementation. Now that the resects are in recession, it is time to find methods that contribute to development, to redouble preventive efforts, to decide what actions will be most effective during the next upsurge. OTA finds that four areas deserve special attention. Each has important implications for the organization of African regional and national efforts and for donor funding.

The Feasibility and Price of Prevention

FAO and USAID maintain that the plague prevention strategy that evolved in the 1960s surveys in seasonal breeding grounds and controling populations as they become gregarious there) could prevent plagues if properly applied. But this depends one fective monitoring and control on a continuous basis, and that is costly. Also, effective spraying is difficult in actuality, partly due to factors beyond the control of donors or governments (civil wars, weather) FAO proposes a major preventive effort in the next 5 years. It seems that such a preventive strategy would be *less expensive* than widespread control but this is undocumented so far. Crisis management mobilizes resources and attention more effectively than preventive approaches to chronic or slow-onset problems, however.

Integrating Emergency Control Programs With Long-Term Development

Far more attention was given to emergency assistance than to other efforts, including preventing insect problems from developing and identifying alternative controls in the recent campaign. For example, nearly all U.S. funds for locust and grasshopper programs in fiscal year 1986 and 1987 were OFDA funds and 58 percent of USAID's major longer term grasshopper and locust project's funds were allocated to emergency assistance for fiscal years 1988 through 1990. Respondents to OTA'S survey agreed that crisis management was the major type of activity undertaken in the recent campaign and most advocated an increase in preventive measures and specific types of relief and rehabilitation.

Individual or Multipest Strategies

Sustainable protection of crops and livestock requires comprehensive, multipest management solutions. Management of all grasshoppers and locusts, however, may not be able to be integrated into single organimations. Some species, e.g., the Senegalese Grasshopper and African Migratory Locust, can be controlled by national crop protection services in programs integrated with efforts against other pests. Others, e.g., the Desert Locust, might be more effectively dealt with regionally as a single species because it breeds in remote areas and migrates among countries.

When and Where Control Efforts Should Be Mounted

During the recent campaigns, vast areas were sprayed with insecticides. The high cost of these efforts, including the less documented environmental costs, require a reexamination of where and when spraying should be done when outbreaks occur. The relative merits of early treatment (e.g.,

FAO's "strategic" control program" aimed at hopper bands in breeding areas) v. later treatment (e.g., when swarms or bands actually threaten crops) are hotly debated. The former may be more costly financially, and the latter politically. Generally, a need exists to improve the precision and accuracy of control efforts. USAID would have to revise its strategy of controlling swarms wherever they occur in order to do this.

What Control To Use: The Role of Technology

Today, widespread insecticide spraying is the predominant technology used against grasshoppers and locusts. Three areas of technolgy seem promising for the future: integrated pest management (IPM), alternative controls, and monitoring insects, weather, and vegetation.

Major elements of 1PM apply during locust and grasshopper upsurges: optimization of control, use of multiple control tactics, keeping pest damage below economic injury level to maintain stable crop production, and minimization of insecticides' hazards. These were not followed in the recent control efforts despite 1PM being USAID's stated policy. This was partly due to lack of technolo and partly due to the poor decision-making and performance by donors and African agencies. Today, biological control, cultural practices, and other nonchemical components of 1PM cannot provide the high level of control needed to stop gregarious swarms. In the future, these methods might, however, contribute significantly when used together or at early states of an infestation. Research on alternatives and improved use of pesticides can be done now and, in fact, must be supported now if alternatives are to be available for future locust and grasshopper upsurges. Experts estimate that it maybe 8 to 10 years or longer before alternatives to insecticides are available for large-scale use.

Biological control (the use or encouragement of natural enemies for the reduction of pests) is one potential component of 1PM. Microbial control methods now being researched include *Nosema* (a protozoa) and viruses that could be incorporated with microbial pesticides. Biorational control methods also include botanical pesticides and pheromone traps, other potential alternatives to synthetic chemical insecticides. The chemicals contained in the neem tree have received attention as a botanical insecticide with antifeedant properties.

Monitoring insects, weather, and vegetation can be done from the ground or from the air. Generally, ground momtoring technologies are adequate, but jurisdictional questions, remoteness of breeding areas, and lack of resources in crop protection services cause them to be used ineffectively. Current technologies for aerial monitoring tend to be imprecise and their results delivered too late. An array of remote sensing satellites has developed. USAID and FAO fund important remote sensing-based early warning systems for locust and grasshopper monitoring. USAID sponsors greenness maps to help guide ground surveys. In 1987, USGS began using U.S. National Oceanic and Atmospheric Administration (NOAA) satellite data to create time-series maps of vegetation changes. FAO began its ARTEMIS (African Real Time Environmental Modeling Using Imaging Satellites) program in 1988 (using Meteosat, the European Space Agency satellite, and NOAA data) to forecast rainfall and monitor changes in vegetation. Currently, remote sensing for early warning of grasshopper and locust upsurges is not considered fully operational.

POLICY OPTIONS FOR CONGRESS AND THE EXECUTIVE BRANCH

Congress and the Executive Branch can take a number of actions to improve pest management in developing countries in general and locust and grasshopper control in particular. Congressional micromanagement of the U.S. foreign aid program is neither desirable, effective, nor OTA's intent, but USAID's inaction or ineffectiveness has left a policy vacuum that Congress may need to fill. Mostly, the need exists for careful congressional oversight of USAID programs–rather than new authorizing legislation–that helps U.S. officials decrease the uncertainty surrounding grasshopper and locust problems (box B).

Box B--High Priority Policy Options for Congress

Chapter 4 sets out detailed oversight questions and policy options and their rationale (see boxes 4-A through 4-D). The following high priority areas are drawn from more extensive set.

Revising USAID Strategy

Oversight Questions:
- justification for widespread pesticide spraying from 1986 to 1989
- revised plans for "next time"

Congressional Options:
- revising USAID's Locust/Grasshopper Strategy Paper for Africa
- reviewing USAID's pest management planning
- implementing the Programmatic Environmental Assessment's recommendations

Implementing Integrated Pest Management (IPM)

Oversight Questions:
- scenarios for different Agency responses
- research on alternative controls
- implementation of IPM
- increased USAID technical capacity
- support for IPM extension and training in Africa

Congressional Options:
- completing USAID's Pest Management Sector Review
- establishing a Pest Management Task Force

Using Pesticides Judiciously

Oversight Questions:
- storage and disposal problems
- more selective and efficient insecticide use
- combined impact of spraying for health and agriculture

Congressional Options:
- specifying more selective, effective, and safe insecticide use

Coordination and Support for African, U.N. and Regional Organizations

Oversight Questions:
- the impact of policy reform
- the benefits of "greenness" maps
- coordination among donors and African countries

Congressional Options:
- setting priorities for various groups' support
- identifying how Congress impedes USAID's impact

SOURCE: Office of Technology Assessment, 1990.

OTA's work builds on several recent studies on pesticide use in developing countries:

- *Opportunities to Assist Developing Countries in the Proper Use of Agricultural and Industrial Chemical (1988, 22);*
- *Locust and Grasshopper Control in Africa/Asia: A Programmatic Environmental Assessment (1989, 95); and*
- *African Emergency Locust/Grasshopper Assistance Project Mid-term Evaluation (1989, 99)*

At least two of these three reports stress: a) the need for increased emphasis on integrated pest management, b) improved use of pesticides, c) assessing the cumulative impacts of control, d) the need for training and technical assistance on topics such as the safe and sound pesticide use, storage, and disposal, e) additional research on alternate control methods, and f) addressing institutional factors that hamper efforts, including needed management changes within USAID.

Revising USAID's Strategy

USAID's approach would require significant changes if the United States wants to play a leadership role in developing sustainable pest management strategies for Africa: giving higher priority to 1PM; building in-house scientific capacity to improve its capacity to use pesticides judiciously; and improving internal, interagency, and international coordination as well as finding improved means to support various other groups involved in pest management.

USAID currently has enough information to revise the Africa Bureau's 1987 ***Locust/Grasshopper Strategy Paper*** and to ensure that the ***Locust/Grasshopper Management Operations Guidebook*** conforms to these revisions and that the recommendations of USAID's Programmatic Environmental Assessments are implemented. OTA finds that Congress might encourage USAID to form a broad Pest Management Task Force to oversee implementation of these recommendations and coordinate the U.S. response to various worldwide plant protection initiatives. Also, the USAID Task Force might commission an external group to evaluate the 1986 through 1989 control programs in Africa. The Task Force might also designate a standing subcommittee on research to solicit, evaluate, and fund 1PM research proposals related to locust and grasshopper control.

Implementing Integrated Pest Management

More fully using 1PM in grasshopper and locust programs will require a sizable investment in research, training of Africans, and improved technical capacity among USAID staff. Since 1PM is a multipronged systems approach, it will require renewed efforts at coordination and drawing together information from a variety of sources: U.S. universities, U.S. and African government agencies, and other donors.

The United States has important capabilities to contribute to improved pest management strategies, but this approach is not well-understood nor fully implemented by those who led the recent grasshopper and locust campaigns. A clear need exists for training African farmers, extension agents, and national crop protection services in 1PM as well as supporting several types of research.

Using Pesticides Judiciously

USAID needs to examine carefully its research, evaluations, and technical assistance regarding insecticides and then incorporate results so that chemicals are used more selectively. Training in safe and effective pesticide use should be a key component of donor crop protection efforts. Donor coordination will be essential if U.S. policies are to have the greatest impact.

Currently, controversy and confusion reign on such issues as the best insecticides to use, the threshold at which to mount control, and the habitats most vulnerable to hazards. USAID could improve this situation by sponsoring further training at all levels, making one person responsible for providing USAID missions with insecticide-related information, preparing and updating country supplemental environmental assessments, and implementing its own staff's suggestions from the last campaign. In some areas, USAID cannot implement measures to improve pesticide use without

congressional action. Granting waivers to certain requirements may help bring about more efficient control.

U.S. Coordination and Support for African, U.N., and Regional Organizations

Many African national crop protection services are poorly equipped to takeover a large part of locust and grasshopper monitoring and control or to develop integrated pest management strategies. Better coordinated regional approaches are needed but support for building individual crop protection services must be a significant part of donor assistance.

Regional groups have a distinct advantage in dealing with regional problems such as migratory pests like grasshoppers and locusts. African regional organizations must continue improving their management and financial support to reach their potential, however. FAO can lead in compiling data, forecasting insect upsurges, and sponsoring meetings; the international agricultural research organizations in Africa can develop alternative control methods. All of these, however, need to integrate their work better with African national agencies.

Local groups' participation in locust and grasshopper control has significant advantages. Their participation can be encouraged via the involvement of African nongovernmental organizations and donors' support for certain types of training, technical assistance, and pilot projects on extension and applied research.

Funding Implications

Some adjustments of U.S. bilateral and multilateral funding maybe necessary to ensure that the most effective pest management is undertaken. Some of monies needed to support improvements in USAID's grasshopper and locust work may come from internal shifts of funds because the Agency is no longer funding massive control efforts. Congress may want to encourage USAID to allocate more of its existing agricultural funds to pest management generally and 1PM specifically. Pest management received a declining share of the Bureau for Science and Technology's agricultural budget in recent years. This trend, coupled with reduced USAID funding to agriculture in general, means that few U.S. development assistance funds are being spent on long term pest management.

Congress replaced USAID's functional accounts with the Development Fund for Africa in 1988 to provide USAID with increased flexibility and to make funding more efficient. Congress could evaluate the impact of the Development Fund. Early indications are that agricultural funding decreased relative to other sectors as a result and pressure to fund activities that seem to have quick, visible results increased. If so, the Development Fund for Africa may neither be achieving its goals, nor be able to serve as a model for other programs.

There is no doubt that some new efforts would require new appropriations. What is not clear is how much these efforts would cost. Implementing 1PM for locusts, grasshoppers, and other pests would require funds for planning, training, research, coordination, and further preventive work such as insect monitoring and forecasting. USAID's planning for follow-on work needs to estimate such costs and present its conclusions to Congress. Certainly some improvements can be made by supplying inexpensive equipment to African organizations, e.g., fax machines, radios, spare parts. Other items, such as satellite receiving stations and major research programs, will be far more costly.

CONCLUSION

Few would argue that the United States has an obligation to assist disaster victims around the world. In some ways, the U.S. response to the 1986 through 1989 locust and grasshopper problems in Africa modeled effective disaster aid: large amounts of resources were mobilized. OTA'S research, however, uncovered distressing questions about whether locusts and grasshoppers constitute a national and international disaster and also whether the U.S. response to the problem was appropriate. It seems that pressure to take action, some coming from Congress, was overwhelming, and the scientific information that could have led to a more suitable approach was misunderstood or overlooked.

U.S. policy takes that road at its peril: massive insecticide spraying in a crisis atmosphere is costly in dollar terms; it tends to be inefficient in the

short-term, ineffective in the medium-term, and misses the roots of problems in the long-term; and the potential health and environmental damage can be high. The alternative path is not readily apparent, however. Africa's pest problems are significant, the solutions are uncertain, and alternatives to chemical control are mostly unavailable. Starting down a different route now is likely to have long term benefits although the results of taking a new direction are likely to be less visible, less dramatic, and perhaps less satisfying for donors in the short-term than spraying millions of hectares with insecticides.